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SCIENCE

FRIDAY, AUGUST 24, 1888.

ASIDE FROM ITS ECONOMIC IMPORTANCE, which cannot be exaggerated, Major Powell's letter to the New Orleans Chamber of Commerce, printed in full on another page of *Science*, on the relief of the alluvial lands of the lower Mississippi from destructive floods, contains the first formal announcement of a new law in the hydraulics of rivers. It is set forth in these words: "The cutting power of a stream increases rapidly with the increase of sedimentary load." This principle was briefly stated by Major Powell in a short oral address before the American Association for the Advancement of Science, about ten years ago, and he has indirectly referred to it two or three times since, in a word or two, in his writings; but this is the first specific statement of it that he has made, and this he considers as barely more than indicating the line of discussion which he has long intended to pursue in a volume that he proposes to write upon the subject. But the principle is stated in this paper with sufficient detail and illustration to arrest the attention of physicists and engineers, and to give rise to an interesting discussion. This Major Powell invites, and the columns of *Science* will be gladly placed at the disposal of any of its readers who may desire to express an opinion, either favorable or unfavorable, to the new theory.

IT IS CHEERING to note that another step in advance in the line of statistical science has recently been taken. A year ago Colonel Wright made a marked impression by demanding that statistics be given a place in the collegiate curriculum. Now the American Statistical Association, which possesses a quiet history of forty years in its records, announces a publication, to appear at regular intervals, devoted to the interests of statistics. This association in the past has been practically but a local society of Boston, formerly fostered by the late Dr. Jarvis, so eminent in the field of vital statistics, and at the present time officered by General Walker (its president), and Mr. Edward Atkinson (its corresponding secretary). The association welcomes to membership all who are interested in statistical work, and hopes in the future to be able to issue a representative journal which may compare favorably with similar European publications. There is no reason why this cannot be done. In no country is the utility and application of statistics more generally recognized than in the United States: it only remains to create an intelligent interest in their proper collection and tabulation. The venture of the publication of a work upon technical statistics, like that of Mr. Pidgin, entitled 'Practical Statistics,' furnishes added testimony to the development in progress. We also understand that during the past year a course upon statistics has been introduced at the University of Michigan, under the direction of Prof. Henry C. Adams.

PREVENTION OF FLOODS IN THE LOWER MISSISSIPPI.

POPULAR interest in the proposed investigation by the United States Geological Survey, of the problem of storing the waters of the upper Missouri and other Far Western rivers in great reservoirs, and the reclamation by irrigation of vast areas of what are now waste lands, spreads as some of the incidental effects of those great works, should they be undertaken, are beginning to be understood. An illustration of this is a letter from the New Orleans Chamber of Commerce to Director Powell, asking him what the effect of the proposed reservoir system will be upon the commercial and agricultural interests of the lower Mississippi. In reply he has prepared and forwarded the following paper, which, aside from the economic possibilities it suggests, is an important contribution to the scientific discussion of the hydraulics of the Mississippi River. The paper is given in full.

The control of the lower Mississippi is a problem of great magnitude, and the conditions are of great complexity. The end to be attained is to give the channel stability of position, and sufficient depth and breadth to make it a perfect conduit, capable of transporting to the sea all the water sent down by floods, thus relieving the adjacent country from danger of overflow. To accomplish this end it is necessary (1) to prevent the choking of the channel by excessive sedimentation, and this is the most important remedy; and (2) to diminish the volume of the floods by the storage of water above at flood-time; this is an accessory but important remedy. The relief of the river from excess of sediment, and the storage of the superabundant water at flood-time, may be accomplished by the same method, and its accomplishment may also involve the irrigation of the arid lands on the eastern slope of the Rocky Mountains. All this must be set forth more fully.

The Mississippi and its tributaries receive and transport to the sea the drainage of about 1,250,000 square miles. To obtain an idea of the work done by this river system, some facts must be understood.

The volume of drainage passing New Orleans is, on the average, 675,000 cubic feet per second, or about 150 cubic miles per year. The average contributions in cubic feet per second of the principal tributaries in the system are, in round numbers, as follows: —

	Cubic Feet per Second.
Upper Mississippi	100,000
Missouri	120,000
Ohio	160,000
St. Francis	30,000
Arkansas and White	60,000
Yazoo	40,000
Red	60,000

A portion of the grand total poured into the valley below Cairo escapes through the Atchafalaya and other bayous even at average river stages, put probably not less than eighty per cent of that total finds its route to the sea at present by way of the Crescent City. During flood-stage the outflow by the same route rises to about one million cubic feet per second; but the rate of inflow into the valley may at such stages exceed twice the carrying capacity of the main branch of the Atchafalaya. Of the three main tributaries, the discharge has been found to rise during floods in the upper Mississippi and Missouri to three times, and in the Ohio to seven times, the average amount.

Such, in brief, are the most apparent facts as to the volume of drainage discharge. But these do not disclose two other facts which are of prime importance in the engineering problems presented by the Mississippi; viz., that this river is a river of mud from the Missouri to the Gulf, and that the Missouri is the principal source of mud-supply.

Much attention has been given recently by the Mississippi River and the Missouri River Commissions to observations of the amount of sediment in transport at various points along the Mississippi and Missouri. These observations show that near New Orleans the amount of sediment in transport varies from $\frac{1}{800}$ to $\frac{1}{7000}$ part of the total volume discharged, and averages about $\frac{1}{2000}$ part of that volume. Above the mouth of the Missouri the Mississippi carries much less sediment, the range being from $\frac{1}{800}$ to $\frac{1}{100000}$, with an average of $\frac{1}{4500}$ part of the volume. The Missouri, on the other hand, is always heavily loaded with sediment. Just above its point of confluence with the Mississippi the amount in transport varies

from $\frac{1}{200}$ to $\frac{1}{5000}$, with an average of $\frac{1}{700}$ part of the volume. Direct measurements on the turbidity of the Ohio do not appear to have been made; but observations on the Mississippi at Columbus, Ky., indicate that the Ohio, like the upper Mississippi, is comparatively free from sediment. The observations just mentioned show, in fact, that the turbidity of the Mississippi at Columbus, Ky., follows closely the turbidity of the Missouri at St. Charles; and it is estimated that more than eighty per cent of the sediment in the Mississippi at Columbus comes from the Missouri. The amount of sediment carried into the Gulf is less certain than the amount poured into the valley at Cairo, since the load brought in by the minor tributaries and the load carried off by the Atchafalaya are unknown. But under any reasonable supposition concerning the carrying capacity of the Atchafalaya, it appears that from $\frac{1}{2000}$ to $\frac{1}{3000}$ of the total discharge into the Gulf is mud; and, on comparing these figures with the corresponding values for the Missouri, it appears that this tributary furnishes from forty to sixty per cent of that mud.

It is seen, then, that the Mississippi from its junction with the Missouri bears onward to the Gulf a load which increases with the accession of every affluent. But the bald figures cited do not readily give an adequate impression of this important fact. Let it be stated, then, in another form, and in numbers more readily grasped. It will suffice to give the output of the Missouri, which has been carefully measured.

The average discharge of sediment from the Missouri is, in round numbers, 170 cubic feet per second, or 500,000 cubic yards per day, or 180,000,000 cubic yards per year. At flood-stage the discharge of sediment has been observed to be as great as 4,000,000 cubic yards per day. The latter amount is equivalent in volume to a levee 100 square yards in cross-section and 23 miles long, and the average annual output would suffice to build more than 1,000 miles of such levee. The volume poured into the Gulf is about twice this output.

Now, what is the effect of this sedimentary load on the course and character of the river from St. Louis to the Gulf? Observations on river-systems, and studies of river-action in general, lead to the recognition of this principle; namely, that the cutting power of a stream increases rapidly with an increase of sedimentary load. A stream with a clear supply cleans and maintains a fixed channel. Gorge a stream with sediment, and its equilibrium becomes unstable. It cuts away its banks here and piles up sediment there, so that the position of the channel is ephemeral; and during flood-stage the burden of water is unloaded upon the adjacent lands. That this may be clearly understood, let it be stated in another way.

When a river receives from a tributary a disproportionately great load of sediment, such sediment is soon deposited, and the channel is thereby choked. This choking is of a peculiar nature; for the sediment is not deposited evenly along the bottom of the channel, but is thrown down in the quiet waters, that is, it is deposited irregularly along the course of the stream, now on one side and now on the other. These irregular deposits turn the current of the stream and throw it against the banks, now on one side and now on the other. By this agency the banks are cut, and the waters of the river are again loaded with sediment, which is again thrown down, and again the stream is turned against its banks and again loaded, and again deposits are made. It is thus that the original overload of sediment is made the occasion for a series of operations, each one of which serves to choke the channel in such a manner that the floods are thrown out upon the adjacent land. As long as a stream running through a flood-plain is overloaded with sediment, just so long will it choke its channel, and just so long will it change the position of its channel, and just so long will it inundate the adjacent lands of the flood-plain at the time of flood.

The action of the Mississippi exemplifies this principle on a grand scale. To appreciate its importance, it is only necessary to consider the tortuous and constantly shifting course of the reach from the Ohio to the Atchafalaya, and the menacing dangers to deep-water navigation along the lower reach. The upper of these reaches is the region of greatest lateral corrasion or bank-cutting. It is here that the abrading materials of the principal tributaries are brought together; and, impelled by the force of an appropriate declivity, they here do their heaviest work. Here they are ground and reground, and dug up and redeposited. Much of the coarser sediment is left, especially during floods, to add to the geological growth of the region, while vast quantities pass on to the sea. The lower reach is at present one of greater stability. The absence of large tributaries, and the escape of floods into the upper basins, give it a steadier flow; and the mud with which it is loaded is more finely comminuted, and hence more easily transported to the Gulf. But the disturbing element is present, and liable at any flood-stage to work disastrous effects.

It must be clearly understood that the diminution of the volume of water in the lower Mississippi is not the prime end to be sought. The prime end to be sought, in order to prevent destructive floods, is to prevent the choking of the channel. The storing of flood-waters on the Ohio and on the upper Mississippi would at first relieve the lower flood-plain; but, on the other hand, the choking of the lower channel would afterward progress at an increased rate, and ultimately the storage of such waters would augment the danger and destruction. But the storage of the waters of the Missouri, and other tributaries that are surcharged with sediment, so as to deposit this sediment on the plains, would permit the purer waters to open a sufficient channel for themselves, and the Mississippi plain would thus be protected. The real problem is to relieve the river of its excess of sediment, and thus prevent lateral cutting and promote vertical scouring, and thus provide adequate channel-room for the greatest floods.

Of the three rivers that contribute the principal volume of flood-waters to the lower Mississippi, the Ohio supplies the largest amount, and is subject to the greatest variation; but when the flood comes, a thousand cubic feet per second extracted from one river diminishes the flood exactly the same as if taken from another.

If the Missouri River be relieved of the enormous quantities of mud supplied to it by the bad-land and sand-plain rivers, it will cease to cut its own banks, and will discharge its waters into the Mississippi, destitute of the sediment coming from these tributaries, and also destitute of the sediment derived from lateral cutting. When the waters of the Missouri are thus delivered to the Mississippi in a comparatively pure condition, they will cease to choke the Mississippi; and the clearer waters of the combined Missouri, upper Mississippi, and Ohio, flowing in one volume as the lower Mississippi, will be able to keep its channel unobstructed.

It will now be readily understood why the storage of the head waters of the Missouri and other western tributaries, and their diversion for the purposes of irrigation, will result beneficially to the agricultural interests and to the navigation of the lower Mississippi. The advantages to navigation and the immunity from floods made possible by storage reservoirs alone are well known; but there should be added to these benefits that which comes from depriving the stream of its chief instrument of corrasion, namely, sediment. Such reservoirs should be constructed along the tributaries of the Missouri, which, as we have seen, is the main source of the sediment-supply of the Mississippi system. Fed by the drainage of the steep slopes of the Rocky Mountains and the bad-lands and the sand-fields of the Great Plains, the waters of the Missouri come loaded with the materials which go on cutting and grinding with constantly increasing energy in their journey to the sea, choking the channel and cutting away the land. Imprison these waters in settling basins, divert them to the purposes of irrigation, and they are robbed of their destructive agency.

It is not maintained that such storage and irrigation works will entirely supplant other resources of the engineering art (revetments, wing-dams, jetties, etc., will still have their uses), but the principal difficulties in the way of the successful application of these resources will disappear with the establishment of the work proposed; and, until such works are constructed, the secondary agencies for the control of the river will be useless.

The waters which are precipitated on the Rocky Mountains, and which roll over the sands and bad-lands of the Plains, are those which directly and indirectly load the Mississippi with its superabundant sediment. These waters are all needed in the arid lands through which they flow, that such lands may be redeemed by irrigation to agricultural purposes. The sediment which they carry can be poured on desert wastes, and render them fertile; and the

channel of the Mississippi from Cairo to its mouth may be relieved of this destroying agency; and the flood-plain valley of the Mississippi itself can be protected from the destroyer; and the channel of the river may be made far more stable, and its cross-section far more uniform, and sufficiently ample to carry the waters of the greatest floods, — all by spreading the rivers of the West over the upper valleys of the Rocky Mountains and over the arid plains. It is thus, and thus only, that the lower Mississippi can be protected; and it is thus, and only thus, that the arid lands can be redeemed. The two problems are inseparably joined. Irrigate the deserts and make them gardens and wheat-fields, and by the same process you protect the flood-plain of the Mississippi and make corn-fields and cotton-fields.

THE THIRTY-SEVENTH MEETING OF THE AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

THE thirty-seventh meeting of the American Association for the Advancement of Science, which was held the past week at Cleveland, O., was not as well attended as the meetings of this great association usually are; but it was nevertheless as successful, and as useful for science, as those of the preceding years. The meeting opened on Wednesday, Aug. 15, with 81 members in attendance. Before the close of the day the number swelled to 258, on Thursday to 303, and on the following day many citizens of Cleveland joined it. A very remarkable feature of this meeting was that only a few citizens of Cleveland numbered on the lists of the first three days, although they showed their interest in the proceedings of the association in other ways, — first of all, by their hospitality, which was very much appreciated by their guests; by attending the evening sessions; and by very full and well-edited reports in the local newspapers. The meeting of the association this year, though not showing as great a number of members attending as last year, and consequently a smaller increase in membership, is remarkable for the great number of eminent scientists taking part in it. The scientific departments of Washington were well represented; and the New England States, as well as all the States from New York to Arkansas and Minnesota, sent most of their prominent scientists.

The meetings were held in the Central High School. In order to bring about closer social meetings between members of the association, brief general sessions were held every morning, and the members met in the hall where these sessions were held. Social intercourse was also promoted by a very enjoyable arrangement of the local committee, who served every day a lunch to the members of the association in the High School, thus inducing them to spend the interval between the morning and afternoon sessions at the school. As the promotion of social intercourse during these meetings is of equal importance with the papers read and the discussions in the various sections, these arrangements are well worth being recorded, and greatly contributed to the success of the meeting.

The programme was similar in character to those of former meetings of the association. The meeting was called to order on Wednesday, Aug. 15, by the retiring president, Prof. S. P. Langley, who resigned the chair to the new president, Major J. W. Powell. A hearty welcome was extended to the members of the association by representatives of the city of Cleveland and of the local committee, to which the president replied, and the sections were organized in their respective halls. At the general meeting the permanent secretary reported on the financial state of the association, from which we were glad to learn that the property of the association has increased materially, and that the research fund, which consists of the contributions of life-members, amounts to more than $4,400.

In the afternoon the vice-presidents of the sections delivered their addresses. In the evening the retiring president, Professor Langley, addressed the association on the subject of the history of the theory of radiant heat, in which address he forcibly brought home the truth that the progress of science is not always on the right line, but that it is only found after many futile attempts, and frequently after long following the wrong track. Thus he proved the importance of the study of the history of science. The address was printed in the last number of *Science*.

On Tuesday a number of geologists had held a meeting, and appointed a committee to bring in a constitution and by-laws for an American geological society. The committee consisted of Prof. A. Winchell of Ann Arbor, John S. Stevenson of New York, C. H. Hitchcock of New Hampshire, Edward Orton of Ohio, and John R. Proctor of Kentucky. On Wednesday, after the organization of the section, a meeting was held, which was well attended, and it was resolved that the society should be formed on the basis proposed by the committee.

On Thursday the sections began their regular sessions, of which a report will be given next week. The important feature of this day was a lecture delivered by President G. Stanley Hall of Clark University of Worcester, Mass. It was the first time that the new psychology had been given a place on the programme of the association; and nobody was better qualified to introduce this important subject in the association than Professor Hall, who was the first to cultivate this branch of science in America. It is to be hoped that this study, now that attention has been called to it, will continue to form part of the proceedings of the association.

Professor Hall gave a brief review of the scope of experimental psychology. He dwelt on the researches made in the study of psychologic physiology, and on the functions of brain and nerves; he mentioned the methods of psychophysic inquiries, and the important bearing of ethnological studies upon psychologic questions. He concluded his sketch, which was listened to with the greatest attention, with a reference to the study of hypnotism, which is one of the most promising fields of psychic research.

On Friday evening Major J. W. Powell delivered a lecture on 'Competition as a Factor in Human Progress.' In his forcible and graphic way, the lecturer gave the results of his study of the history of civilization and of human progress, which is based on his views as an ethnologist. He compared the evolution of society to that of animals and plants, and showed that the term 'survival of the fittest' does not apply in the same way in sociology and in biology.

Saturday was devoted to an excursion to Put-in-Bay, one of the islands in the western extremity of Lake Erie. The day was very pleasantly spent, the weather being fine. The remarkable glacial striæ of Kelley's Island were visited on this trip.

SCIENTIFIC NEWS IN WASHINGTON.

The Latest Public-School Statistics: Some Interesting Figures and Comparisons of School Population, Enrolment, and Attendance. — Plastering Wines in France: a Searching Investigation by the French Academy of Medicine: Adverse Report.

School Attendance in the United States.

THE annual report of the United States commissioner of education for 1886–87 is now going through the press at the Government Printing-Office, but copies of the volume will not probably be ready for distribution until next winter. The report of Commissioner Dawson, besides giving the usual statements of the organization and administration of his office, is supplemented with an explanation of his plan to publish in a series of monographs a history of education in the United States, and an account of his visit to Alaska, with suggestions as to the education of the people of that far-off Territory.

The commissioner's statement is followed by twenty-two chapters, which, in addition to presenting the usual statistics, digests of State school reports, etc., treat of the training of teachers, kindergartens, secondary instruction, superior instruction, professional instruction, manual and industrial training, education of special classes, libraries in the United States, and many other important educational subjects, and a chapter of papers on important educational topics by men of recognized authority on the subjects upon which they write.

In addition to the usual statistical tables accompanying the report, Commissioner Dawson has directed the preparation of several new and quite important ones, and the addition of new columns to some of the old ones. This work has been done by Mr. F. E.